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**AN EXPANDABLE BLADDER FOR TYRE-CURING APPARATUSES, A
MANUFACTURING METHOD THEREOF, AND A PROCESS FOR
MANUFACTURING TYRES FOR VEHICLE WHEELS**

5 D e s c r i p t i o n

The present invention relates to an expandable bladder
for tyre-curing apparatuses made up of two or more
elastomer materials having different compositions,
10 disposed in several mutually-coupled layers, for
example.

It is also an object of the invention to provide a
method of manufacturing said bladder.

15 In the embodiments that will be disclosed in the
present description, the invention is conceived to be
utilised within the scope of tyre manufacturing
processes, and more particularly in the moulding and
20 vulcanisation steps of previously built green tyres.

It is known that in the manufacture of tyres for
vehicle wheels a moulding and vulcanisation treatment
is provided subsequently to a step involving building
25 of the green tyre by assembling of the respective
elastomer material components with appropriate
reinforcing structures, said moulding and vulcanisation
treatment aiming at determining the structural
stabilisation of the tyre, by cross-linking of its
30 elastomer components and, if required, imparting a
desired tread pattern thereto as well as possible
graphic marks at the sidewalls.

To this aim, the green tyre is introduced into a
35 suitably heated vulcanisation mould having a moulding

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cavity conforming in shape to the final conformation to be given to the tyre itself. After carrying out closing of the mould, a bladder of toroidal shape is allowed to expand within the tyre, which bladder in a radially internal position has at least one circumferential edge carrying tailpieces for anchoring to respective parts of the mould. Bladder expansion is obtained by admitting steam under pressure thereinto, so as to bring the bladder into contact with the inner tyre surface and compress the tyre against the moulding cavity walls, with simultaneous heat transmission in an amount required for cross-linking.

When vulcanisation has been completed, the mould is opened to allow removal of the tyre and set the mould ready for a new vulcanisation cycle.

However, it is necessary to prevent the bladder from adhering to the inner walls of the tyre too much, to promote both adaptation of the bladder to the tyre conformation and tyre removal without any risk of damage at the end of vulcanisation.

As known, this requirement is tackled by resorting to surface treatments essentially consisting in disposing appropriate release agents usually applied by spraying, on the outer bladder surfaces and/or the inner tyre surfaces.

These treatments however involve different problems originating from the material employed as the release agent and the equipment and time required for carrying out the treatment itself. Surface treatments can also create problems in terms of environmental impact, because the materials used as the release agents can be

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dangerous, as well as in terms of production rejects that may occur each time the surface treatment is not uniformly carried out over the whole bladder/tyre contact surface..

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The state of the art proposes different solutions to reduce adhesion of the vulcanisation bladder to the tyre surfaces. For instance, document JP 63125311 discloses how to manufacture an expandable bladder with
10 an elastomer composition comprising an organic rubber and a polyorganosiloxane containing a specific silicone-modified elastomer as the solubilizing agent.

In document JP 5031724 use of an expandable layered
15 bladder is proposed which has an inner elastomer layer consisting of butyl rubber and an outer elastomer layer consisting of silicone rubber. The inner layer of butyl rubber ensures a hermetic seal to steam under pressure, whereas the outer layer of silicone rubber facilitates
20 sliding of the bladder on the inner tyre surfaces and release therefrom when vulcanisation is over.

The Applicant however has found that in manufacturing bladders of this type several difficulties are
25 encountered for obtaining an efficient and reliable union between the inner and outer layers because they are made of different elastomer materials. In particular, the butyl and silicone polymeric bases are not very compatible with each other because they are
30 not able to carry out cross-linking together, i.e. to form stable molecular bonds with each other, which impairs reliability and duration of the layered bladders made in accordance with the known art.

35 The Applicant has perceived that for obtaining a

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process advantageously employing a layered bladder it is necessary to provide an efficient attachment means between non compatible blends like the butyl one and silicone one, in order to avoid the above mentioned
5 problems.

The Applicant has found that manufacturing the different layers of said bladder in such a manner as to obtain a mechanical engagement between the surfaces in
10 contact makes it possible to produce bladders made of non compatible blends that are very reliable and of long duration for use internally of a tyre vulcanisation apparatus, because the forces tending to separate the different layers as a result of the
15 moulding pressure are counteracted by the constraining reactions generated between the contact surfaces of the different layers as a result of said mechanical engagement.

20 More specifically, in accordance with the present invention, the different materials required in manufacturing a layered bladder are arranged in the form of a continuous elongated element and mutually coupled before or during winding of same on a toroidal
25 support, so as to obtain a layered coating in which the materials are mutually joined according to an undulated interface profile defining complementary elements of mechanical engagement between the materials themselves. By suitably selecting the shape and mutual arrangement
30 of the elongated elements, the conformation of the undulated interface profile can be controlled with a wide margin, for example as regards the wave width and pitch, so as to increase the coupling surface between the materials.

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It is therefore an object of the invention to provide an expandable bladder for tyre vulcanisation apparatuses, as defined in claim 1.

- 5 It is a further object of the invention to provide a method of manufacturing said bladder, as defined in claim 9.

The invention also proposes a new process and a new
10 apparatus for tyre vulcanisation, as defined in claims 32 and 34 respectively.

Further features and advantages will become more apparent from the detailed description of a preferred
15 but not exclusive embodiment of an expandable bladder for tyre-vulcanising apparatuses, of the related manufacturing method, as well as of a process and apparatus for manufacturing tyres for vehicle wheels in accordance with the present invention. This description
20 will be set out hereinafter with reference to the accompanying drawings, given by way of non-limiting example, in which:

- Fig. 1 diagrammatically shows, in diametrical section, a vulcanising apparatus incorporating an
25 expandable bladder in accordance with the invention, during its expansion step within the tyre to be vulcanised;
- Fig. 2 is a fragmentary cross-section view of the bladder in Fig. 1 to an enlarged scale;
- 30 - Fig. 3 laterally shows a diagram of the simultaneous laying of a first and a second elongated elements on a toroidal support, for the purpose of manufacturing the expandable bladder in reference;
- Fig. 3a laterally shows a diagram of the simultaneous
35 laying of a first and a second elongated elements on a

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toroidal support, in accordance with a possible alternative embodiment;

- Fig. 3b laterally shows a diagram of the simultaneous laying of a first and a second elongated elements on a

5 toroidal support, in accordance with a further alternative embodiment;

- Fig. 4 diagrammatically shows a continuous strip-like element in cross section to be obtained from mutual coupling between the first and second elongated
10 elements, close to the plane along line IV-IV in Fig. 3 for example;

- Fig. 5 shows, by way of example, a deposition diagram of the continuous strip-like element in the form of coils disposed close to each other to obtain an
15 expandable bladder as shown in Fig. 2;

- Fig. 6 diagrammatically shows a continuous strip-like element in cross-section to be obtained by coupling a first and a second elongated elements into a triangular conformation, according a possible alternative
20 embodiment of the invention;

- Fig. 7 is a fragmentary section view of a deposition diagram of the continuous strip-like element in Fig. 6 in the form of coils disposed close to each other.

25 With reference to the drawings, an expandable bladder for tyre-vulcanising apparatuses in accordance with the present invention has been generally identified by reference numeral 1.

30 Bladder 1 lends itself to be employed in combination with a vulcanisation apparatus generally denoted at 2 in Fig. 1, comprising a mould 3 having a plurality of cheeks 4 and sectors 5 that, when the mould is closed, define a moulding cavity adapted to receive a tyre
35 being processed.

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Bladder 1 of a substantially toroidal conformation, has at least one circumferential edge, and preferably two edges carrying respective anchoring tailpieces 1a, to be sealingly engaged in mould 3 to operatively associate the bladder itself with apparatus 2. A duct 7 for feeding steam or other working fluid and formed in mould 3 opens into said bladder 1 so as to enable bladder expansion following admission of steam under pressure, to compress tyre 6 against cheeks 4 and sectors 5. By effect of pressing, appropriate land portions arranged on sectors 5 and cheeks 4 cause formation of a desired tread pattern on the thread band of tyre 6, as well as a plurality of graphic marks on the tyre sidewalls.

Also operatively associated with mould 3 at cheeks 4 and/or sectors 5 are devices designed to supply heat to the green tyre 6 to be vulcanised, which devices cooperate with the steam introduced into the expandable bladder 1 to cause cross-linking of the elastomer material of which the tyre itself is made.

When the cycle has been completed, the moulded and vulcanised tyre 6 is disengaged from the expandable bladder 1 and extracted from mould 3, after opening of the latter.

The expandable bladder 1 is advantageously comprised of at least one first layer 8 of a first elastomer material, and one second layer 9 of a second elastomer material different from the first elastomer material and placed at a radially external position with respect to the first layer 8. The first and second layers 8, 9 are advantageously coupled at an undulated

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interface profile 10 defining mechanical-engagement elements 10a between the first and second layers 8, 9.

In...a... preferential...embodiment, the first elastomer material forming layer 8 placed at a radially internal position consists of a butyl-based blend so as to ensure a hermetic seal to steam under pressure fed into the expandable bladder 1.

10 The second elastomer material forming the second layer 9 in turn preferably consists of a silicone-based blend, so as to promote sliding of bladder 1 against the inner surface of tyre 6 in the expansion step, and allow an easy release of bladder 1 from tyre 6 when
15 vulcanisation is over.

As shown in Fig. 2, a wave pitch P and a wave height H can be identified in the undulated interface profile 10. In the present description and in the following
20 claims by wave "pitch" of the interface profile it is intended the distance P measured in an axial direction in right section between the median points of two consecutive waves. In the context of the present definition, the median point of each wave is the mean
25 point of segment "n" joining the opposite radially inner ends of said wave. In Fig. 2 the line Z on which value P is indicated is parallel to the geometric axis of bladder 1 and therefore represents the axial direction.

30 Finally, in the present description and in the following claims by "height" of each wave of said interface profile it is intended projection H on a plane E parallel to the equatorial plane of bladder 1,
35 of a segment "m" extending in a right-section plane

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perpendicularly to segment "n" joining said radially inner wave ends, or to the extension of the segment itself, between said segment or the segment extension and the radially outermost point of the wave.

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To enable an efficient mechanical engagement between layers 8 and 9, the wave height H is preferably equal to or higher than one tenth of, and preferably higher than half the wave pitch P, so as to obtain effective mechanical-engagement elements 10a also in the absence of undercuts.

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In the embodiment shown in Fig. 2, the wave height H is as high as about five times the value of the wave pitch P.

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In addition or as an alternative to the above description, the complementary mechanical-engagement elements 10a defined by the interface profile 10 may be provided to have portions 10b of mutual undercut constraint, as shown in Fig. 6.

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As viewed from Figs. 5 and 7, a third layer of elastomer material 11 may be further provided, said layer being disposed at a radially internal position to the first layer 8 and being cross-linked with the elastomer material forming the first layer.

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If required, a fourth layer of elastomer material 12 may be also arranged at a position radially external to the second layer 9, said fourth layer being cross-linked with the elastomer material belonging to at least the second layer itself.

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In a preferential technical solution, the bladder has

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an overall thickness S included, just as an indication, between 3 and 8 mm, equal to about 5 mm for example. The radially internal portion of bladder 1 formed of the...first...layer..8 and the possible third layer. 11. 5 preferably has a thickness, measured with reference to a median line L of the undulated interface profile 10, greater than 1/2 and preferably corresponding to at least 3/5, of the overall thickness S of the bladder.

10 The thickness of the radially external portion of bladder 1, made up of the second layer 9 and the possible fourth layer 12, will be advantageously reduced to no more than half the overall thickness S, to the benefit of the bladder manufacturing costs, 15 since the butyl-based blend is less expensive than the silicone-based blend.

Manufacture of the expandable bladder 1 described above contemplates preparation of a first elongated element 20 13 and a second elongated element 14 made of the first and second raw elastomer materials, respectively. The first and second elongated elements, obtained by extrusion and fed from a first 15 and a second 16 extruder respectively, are guided to at least one 25 roller 17 or other delivery member that lay them down on a deposition surface 18a of a toroidal support 18 of a shape matching that of the expandable bladder to be obtained. The toroidal support 18 is preferably supported by a robotized arm 19 only partly shown as 30 known from document WO 00/35666 A1 in the name of the same Applicant. The robotized arm 19 gives the toroidal support 18 a circumferential-distribution rotatory motion around the geometric rotation axis X thereof, by effect of which a circumferential distribution of the 35 elongated elements 13, 14 laid by the delivery roller

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17 on the deposition surface 18a is caused.

Simultaneously, the robotized arm 19 moves the toroidal support 18 in front of the delivery roller 17 by controlled ..relative.. displacements of transverse.
5 distribution, so that the first and second elongated elements 13, 14 laid on the deposition surface 18a are formed into coils wound around the geometric axis X of the toroidal support 18.

10 On coming out of the respective extruders 15, 16, the first and second elongated elements 13, 14 are guided in converging directions with respect to each other, towards a point of mutual coupling in which the elongated elements themselves meet and adhere to each
15 other forming a continuous strip-like element 20 that is laid and distributed on the toroidal support 18 as above described.

In the example in Fig. 3, the coupling point of the
20 elongated elements 13, 14 is coincident with application of same to the toroidal support 18 by the delivery roller 17. However said elongated elements 13, 14 can be also guided in such a manner as to cause coupling of same at a point upstream of the toroidal
25 support 18. It may be also provided that the continuous strip-like element 20 should come from a supply reel, used in a storage step of the strip-like element itself after carrying out mutual coupling of the elongated elements 13, 14.

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In a further alternative embodiment, the elongated elements 13, 14 can be co-extruded and directly coupled in the extrusion head of a single extruder 26 (Fig. 3b) so that the strip-like element 20 is directly generated
35 at the extruder outlet.

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Finally, in a different embodiment shown by way of example in Fig. 3b, the elongated elements 13, 14 can be simultaneously laid on the toroidal support 18 at points A, B that are mutually spaced apart in a circumferential direction. In this instance, the coupling point between the elongated elements is coincident with the application point of the second elongated element 14 onto the toroidal support 18.

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As can be viewed from Figs. 4 and 6, the elongated elements 13, 14 are mutually coupled in such a manner that, when coupling has occurred, each of them has a base portion 21, 22 in contact with the base portion of the other elongated element. In addition, at least one of the elongated elements 13, 14 may have an apex 23, 24 projecting from the base portion 21, 22, in a direction transverse to the direction of mutual alignment of the base portions themselves, denoted at D in said figures.

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In more detail, in a preferential embodiment the elongated elements 13, 14 that can have a conformation substantially identical with each other, are coupled at mutually offset positions in a plane transverse to the mutual alignment direction D of the base portions 21, 22, so that each of them has a respective apex 23, 24 projecting in the opposite direction with respect to the apex of the other elongated element.

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During laying on the toroidal support 18, mutual positioning of the elongated elements 13, 14 and/or orientation of the continuous strip-like element 20 formed by them is controlled in such a manner that, on coming close to the deposition surface 18a, the apex 23

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of the first elongated element 13 is turned towards the toroidal support 18.

As can be clearly seen looking at Figs. 5 and 7, apex 23 of the first elongated element 13 of butyl material, during application is deformed and it consequently bends towards the base portion 22 of the second elongated element 14, taking an interposed position between the second elongated element 14 and the toroidal support 18 so as to avoid a direct contact of the second elastomer material against the deposition surface 18a.

At the deposition surface 18a, the coils disposed consecutively in side by side relationship and formed by the first elongated element 13, by effect of bending of apex 23 as above described, give rise to a continuous layer of butyl material extending over the whole deposition surface 18a.

Apex 24 of the second elongated element 14, in turn, is oriented radially away from the deposition surface 18a presented by the toroidal support 18 and can be turned up against the base portion 21 of the first elongated element 13, so that the coils in side by side relationship formed by the second elongated element 14 cause formation of a continuous layer of silicone material.

If required, turning up of apex 24 of the second elongated element 14 can be assisted by a roller or other auxiliary applicator member 25, operating downstream of the delivery roller 17.

As a result of the deposition in the form of coils in

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side by side relationship, in addition, the base portions 21, 22 of the first and second elongated elements 13, 14 generate the interface profile 10 between the first and second layers.

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If required, application of the first and second elongated elements 13, 14 can be preceded by application of the third layer 11 of butyl material or in any case of a material suitable for cross-linking with the first elastomer material forming the first
10 elongated element 13. Formation of this third layer can take place in the same manner as previously described with reference to laying of the continuous strip-like element 20, i.e. through application of a continuous
15 elongated element of elastomer material, coming from an extruder for example and formed into coils disposed consecutively in side by side relationship to cover the deposition surface 18a of the toroidal support 15.

20 Subsequently to laying of the first and second elongated elements 13, 14, application of the above mentioned fourth layer 12 may be also carried out, said layer being made of a silicone material or at all events a material suitable for cross-linking with the
25 second elastomer material forming the second elongated element 14. Formation of the fourth layer 12 too can be carried out by applying a fourth elongated element of elastomer material coming from an extruder and formed into coils disposed consecutively in side by side
30 relationship. The third and fourth elongated elements 11, 12 can be advantageously produced either by the same extruders 15, 16 used for formation of the first and second elongated elements 13, 14, or by specific extruders dedicated thereto.

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In the presence of the third and/or fourth elastomer layers 11, 12, arrangement of apices 23, 24 projecting from the first and second elongated elements 13, 14 respectively... may appear to be superfluous, as said.
5 third and fourth layers can be cross-linked with the material forming the base portions 21, 22 of the elongated elements 13, 14, respectively.

As shown in Fig. 5, the elongated elements 13, 14 can
10 have a conformation with a substantially flattened cross-section. In this case an interface profile 10 as shown in Fig. 2 is preferably obtained, in which the wave height H is greatly higher than the wave pitch, so that the hills and valleys of the undulated profile
15 will cause formation of the mechanical-engagement elements. Alternatively, as exemplified in Figs. 6 and 7, the elongated elements 13, 14 can advantageously have a cross-section profile of triangular conformation. In this case the base portions 21, 22 of
20 the coupled elongated elements 13, 14 give rise to formation, in the mechanical-engagement elements 10a, of portions 10b with an undercut constraint. The same effect is achieved using elongated elements 13, 14 having a trapezoidal cross-section profile.

25 When formation of layers 8, 9, 11, 12 on the toroidal support 18 has been completed, the expandable bladder 1 lends itself to be introduced into a mould to be submitted to a moulding and vulcanisation step that can
30 be carried out in any convenient manner. During this step, in the same mould as used for moulding and vulcanisation of the bladder it is possible to inject elastomer material for causing formation of said third and/or fourth layers 11, 12 and/or of any other
35 additional coating layer.

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The present invention achieves important advantages.

In fact, any problem resulting from the difficulty of
5 joining a silicone blend to a butyl blend in a steady
and reliable manner can be brilliantly overcome so as
to manufacture a very durable and reliable expandable
bladder that eliminates the necessity to carry out
surface treatments in order to promote adaptation of
10 the bladder to the inner tyre conformation and removal
of the tyre itself when vulcanisation has been
completed.

In addition, the bladder in reference lends itself to
15 be made in a simple and cheap manner, utilising
machinery and equipment already provided in modern
tyre-production cycles in which the elastomer
components are obtained by winding elongated elements
of raw elastomer material in the form of coils disposed
20 in side by side relationship on a toroidal support, as
described in document WO 00/35666 A1 in the name of the
same Applicant.